SPLIT SAMPLING EVENT DATA REVIEW AND DISCUSSION

Data collected at the Homestake Mining Company Grants site by USGS and HMC/Arcadis in 2016

April 30, 2018

90041457

Meeting Agenda

10:00 – 10:10 Building Safety Overview, Introductions, and Safety Share

10:10 – 10:20 Meeting Objectives

10:20 – 11:30 Arcadis Presentation 2016 Split Sampling Results, Passive Sampler Data, and Geophysics

11:30 – 12:30 USGS Presentation 2016 Sampling Results and Geophysics

12:30 – 1:00 General Discussion

Arcadis presentation

- H&S moment
- HMC Grants Mill site overview
- Split sampling results and water chemistry
- Passive samplers and bench testing
- Geophysics
- Wells DD-3, DD-4, DD-5
- Conceptual Site Model revision, geological logging, and soil sampling
- Conceptual Site Model for groundwater

Health and Safety Moment

Wash your car regularly

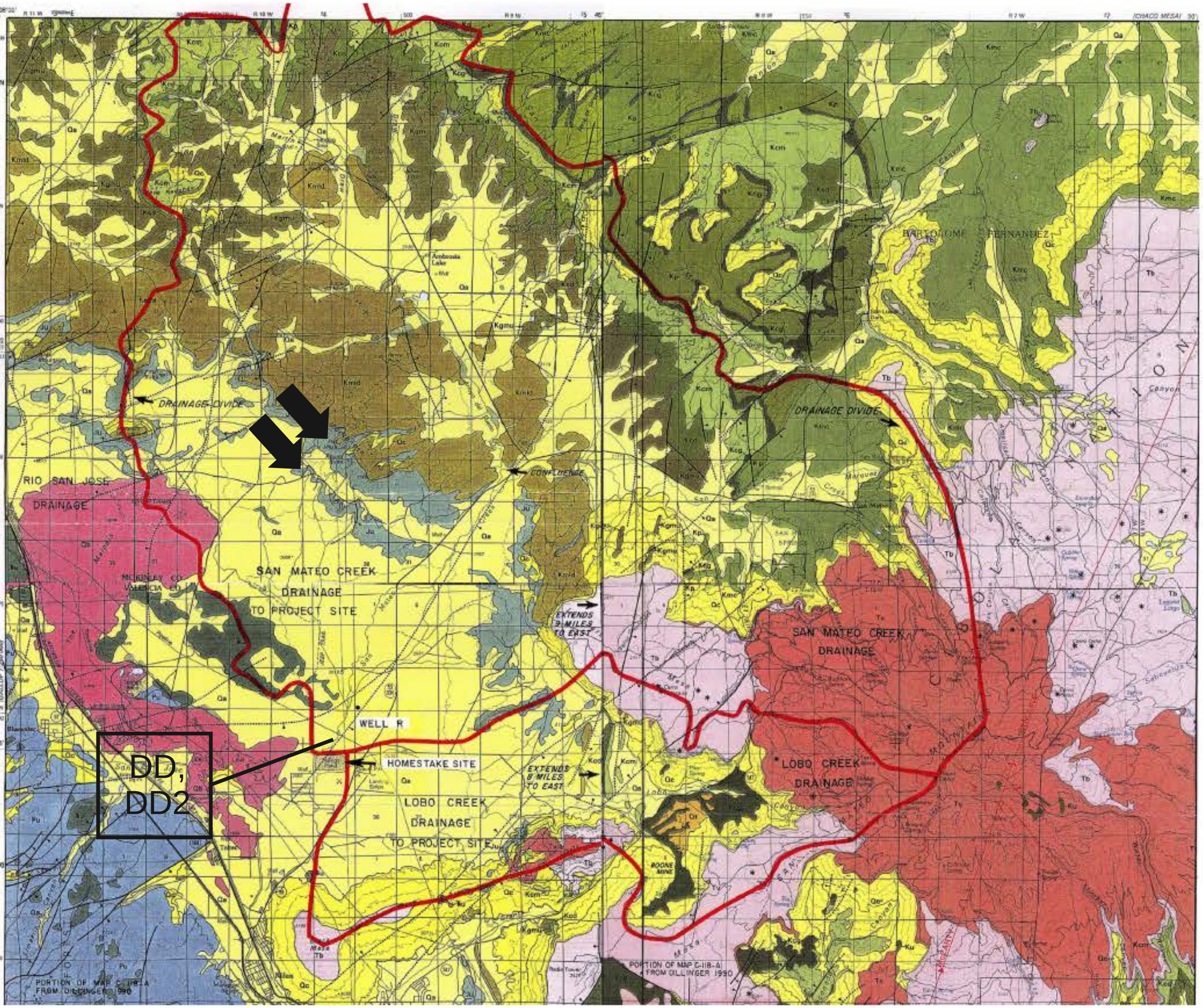
Hazards resulting from a dirty car

- Poor visibility for driver
  - Dirty windows
  - Angle of sun
  - Headlights
- Poor visibility for other drivers
  - Obscured headlights, tail lights, and blinkers
- Mechanical health and longevity
  - Road salts = corrosion

http://www.iowastatedaily.com/special_sections/auto/article_bad1635e-1a4a-11e7-a62a-1ffaa03b49e5.html

HMC Grants Mill site

San Mateo Creek Basin Geology



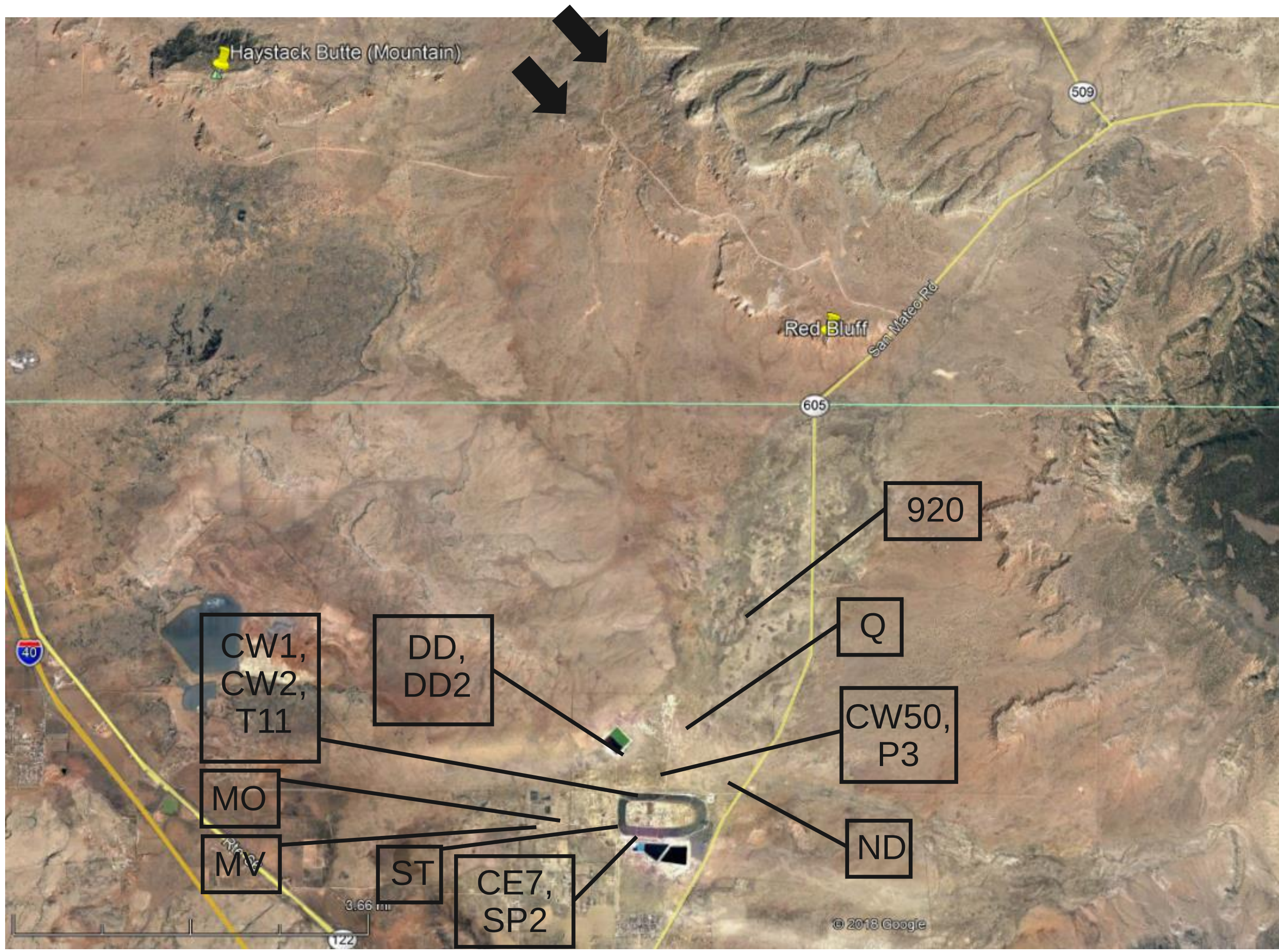
LEGENDS: Correlation of Map Units

Source:
Dillinger, J.K., 1990, Geologic map of the Grants 30' x 60' quadrangle, west-central New Mexico: U.S. Geological Survey, Coal Investigation Map C-118-A, scale 1:100,000.

GRANTS RECLAMATION PROJECT
Updated Corrective Action Program (CAP)

FIGURE 3.1-1
BEDROCK GEOLOGY

San Mateo Creek Basin Geology



San Mateo Creek Basin Geology

Alluvium is from eroded highlands

This rock contains ore-grade uranium

Results in disseminated uranium-containing particles in alluvium

Erosion/fluvial deposition is a heterogeneous process (visible)

Split sampling event: Summer 2016

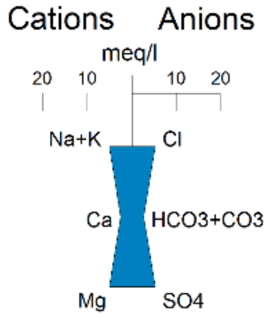
Comparison of Split Sampling Results – Available Data

Samples collected via 3 methods: volumetric, micropurge, passive sampler

- ❑ Missing all passive sampler data
- ❑ Metals:
  - ❑ missing total uranium from DD, DD-2, MV, ND, Q, T-11 volumetric purge samples
  - ❑ missing dissolved uranium from T-11 volumetric purge sample
  - ❑ missing all uranium from DD, DD-2, MV, ND, Q, T-11 micropurge samples
  - ❑ missing selenium from DD micropurge sample

- ✓ Major anions and cations
- ✓ Nitrogen compounds
- ✓ Alkalinity
- ✓ Total organic carbon
- ✓ Radionuclides
- ✓ Isotopes
- ✓ Dissolved gases (CFCs)
- ✓ Geophysical data
- ✓ Field parameters
- ✓ Field Hach analyses: dissolved oxygen and ferrous iron

Split sampling data and major water chemistries



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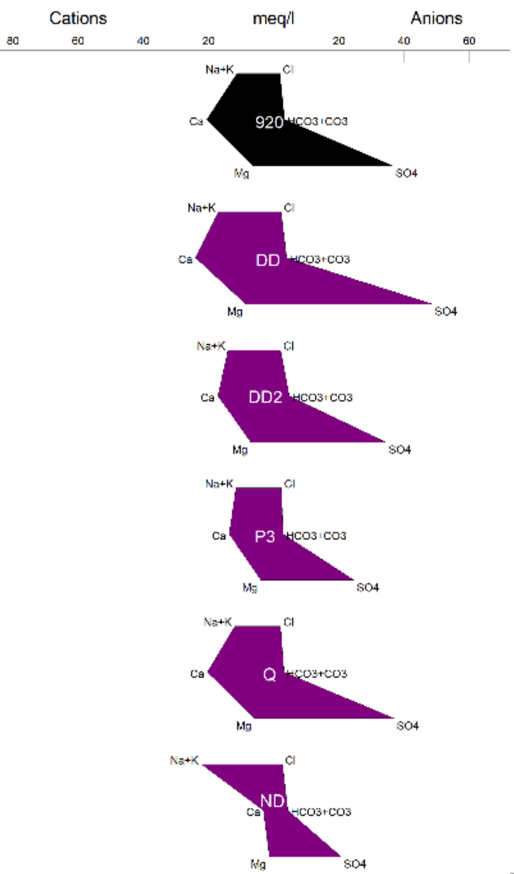
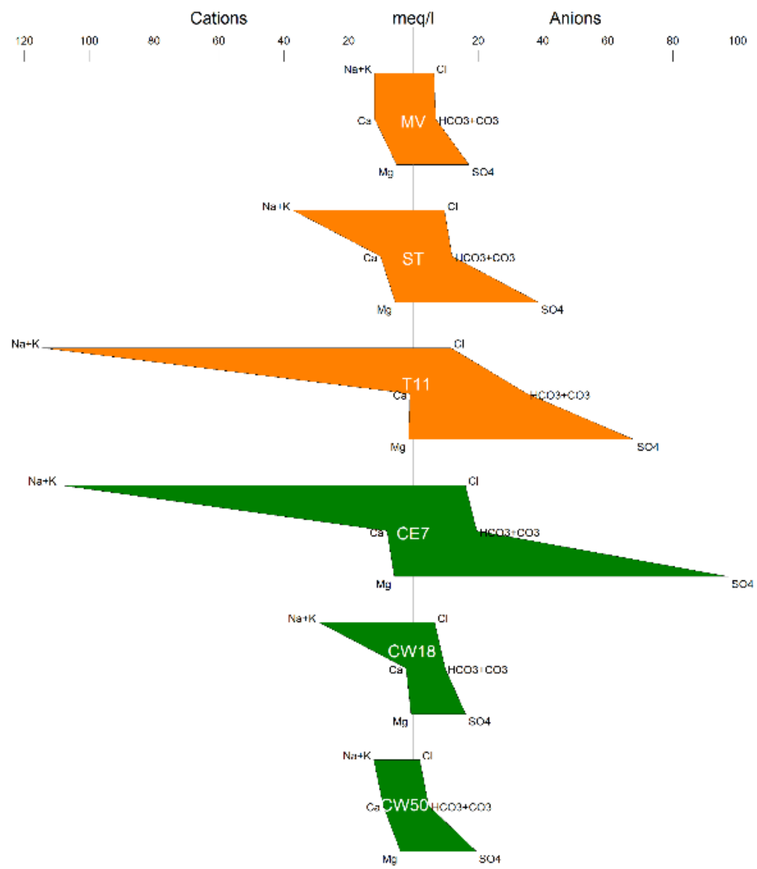
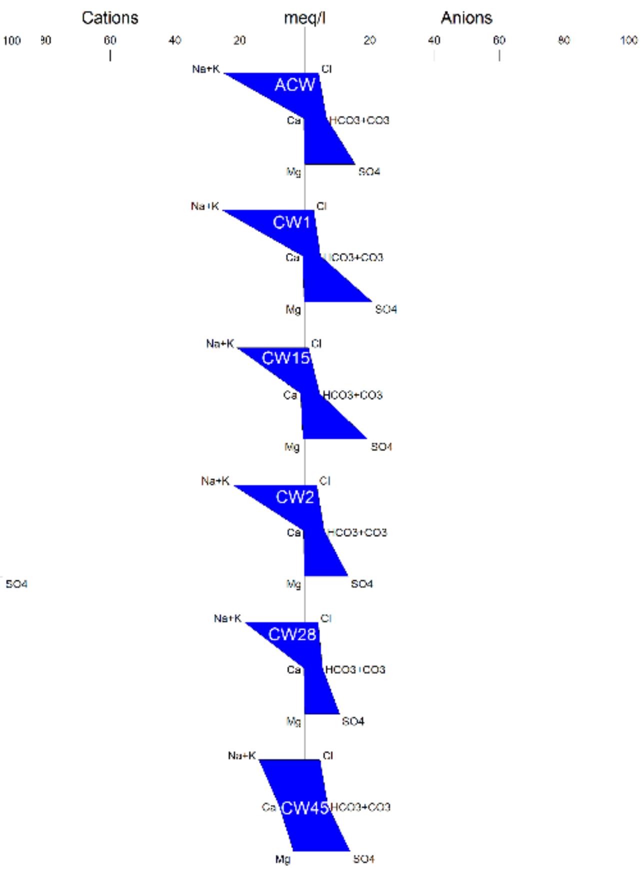
Stiff Diagrams: Upgradient wells

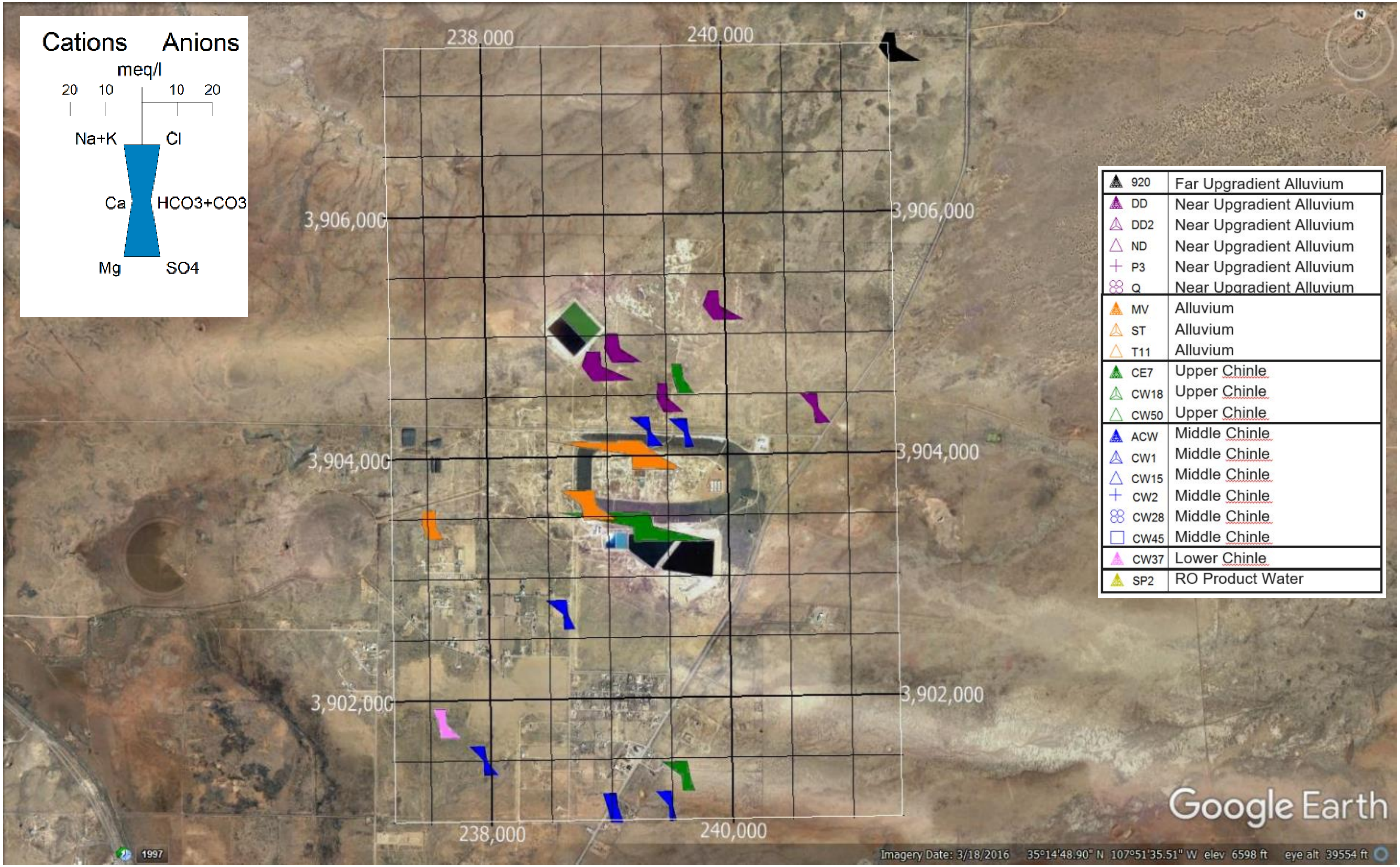


Alluvium (orange) and Upper Chinle (green)



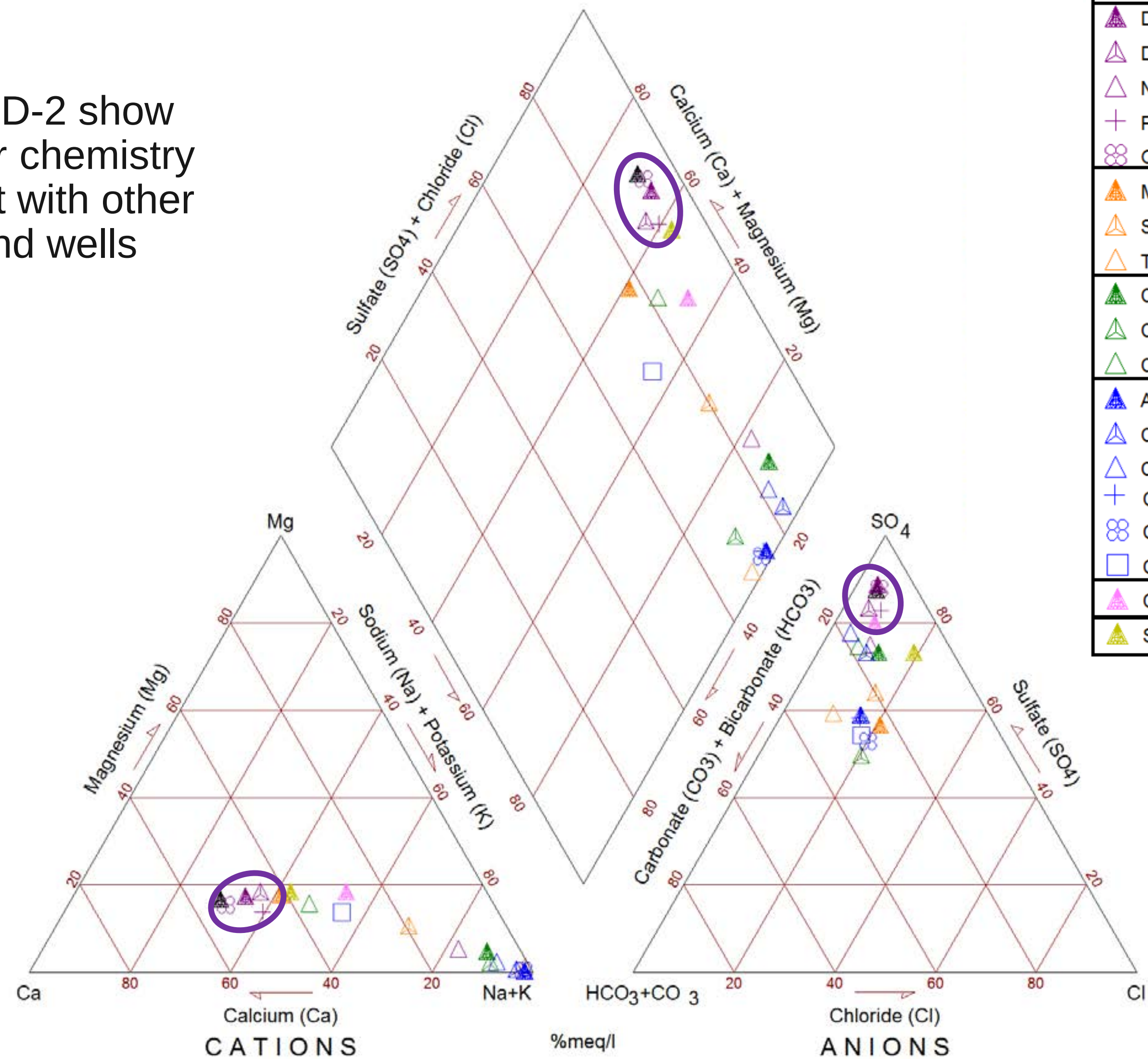
Middle Chinle




Cations
Anions
meq/l
20 10 10 20
Na+K
Cl
Ca
HCO3+CO3
Mg
SO4
238,000
240,000
3,906,000
3,904,000
3,902,000
920 Far Upgradient Alluvium
DD Near Upgradient Alluvium
DD2 Near Upgradient Alluvium
ND Near Upgradient Alluvium
P3 Near Upgradient Alluvium
Q Near Upgradient Alluvium
MV Alluvium
ST Alluvium
T11 Alluvium
CE7 Upper Chinle
CW18 Upper Chinle
CW50 Upper Chinle
ACW Middle Chinle
CW1 Middle Chinle
CW15 Middle Chinle
CW2 Middle Chinle
CW28 Middle Chinle
CW45 Middle Chinle
CW37 Lower Chinle
SP2 RO Product Water
Google Earth
1997
Imagery Date: 3/18/2016 35°14'48.90" N 107°51'35.51" W elev 6598 ft eye alt 39554 ft

DD and DD-2 group with far upgradient well 920

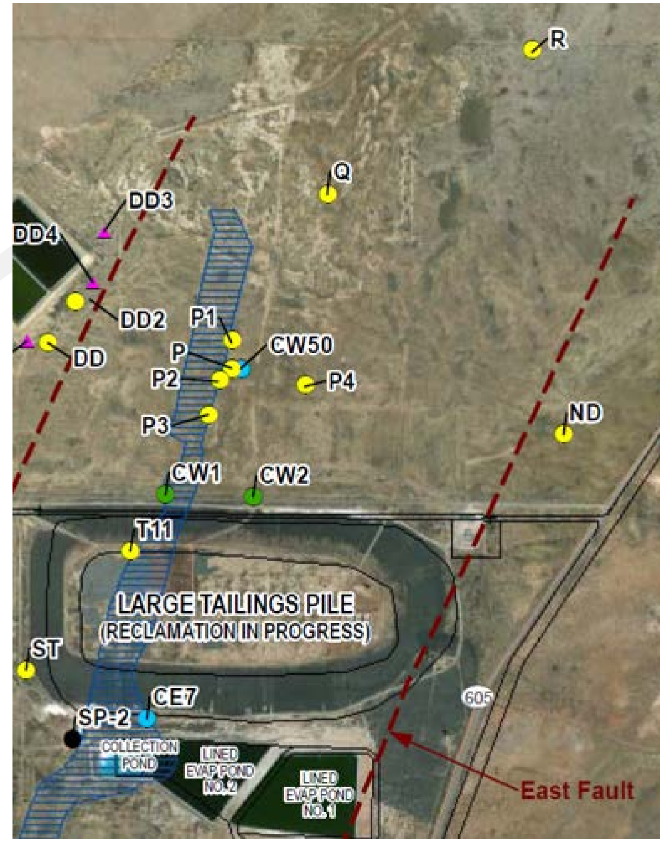
DD and DD-2 show bulk water chemistry consistent with other background wells

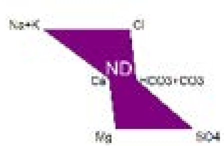


920	Far Upgradient Alluvium
DD	Near Upgradient Alluvium
DD2	Near Upgradient Alluvium
ND	Near Upgradient Alluvium
P3	Near Upgradient Alluvium
Q	Near Upgradient Alluvium
MV	Alluvium
ST	Alluvium
T11	Alluvium
CE7	Upper Chinle
CW18	Upper Chinle
CW50	Upper Chinle
ACW	Middle Chinle
CW1	Middle Chinle
CW15	Middle Chinle
CW2	Middle Chinle
CW28	Middle Chinle
CW45	Middle Chinle
CW37	Lower Chinle
SP2	RO Product Water

Well ND

- Location: Eastern side of alluvial channel
- Geology: alluvium to 65 ft, underlain by shale
    - Log describes sands and gravely sands
- Well construction: depth 70 ft, 4-inch, DTW 47.63 ft
- Screen interval: 50-70 ft, across sands, Chinle Shale
- Geochemistry: Has similar piper plot trend as many wells screened in the Chinle Aquifers
- Uranium:
    - Relatively uniform trace for soils with similar peak heights as per DD and DD2
    - Low U concentration in groundwater
- Observations:
    - Well appears to be a geochemical outlier when compared to other background wells
    - Geological/hydrogeological interaction other than just alluvium must be occurring in this area

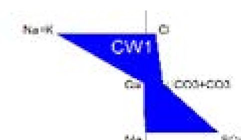




ND

Alluvium

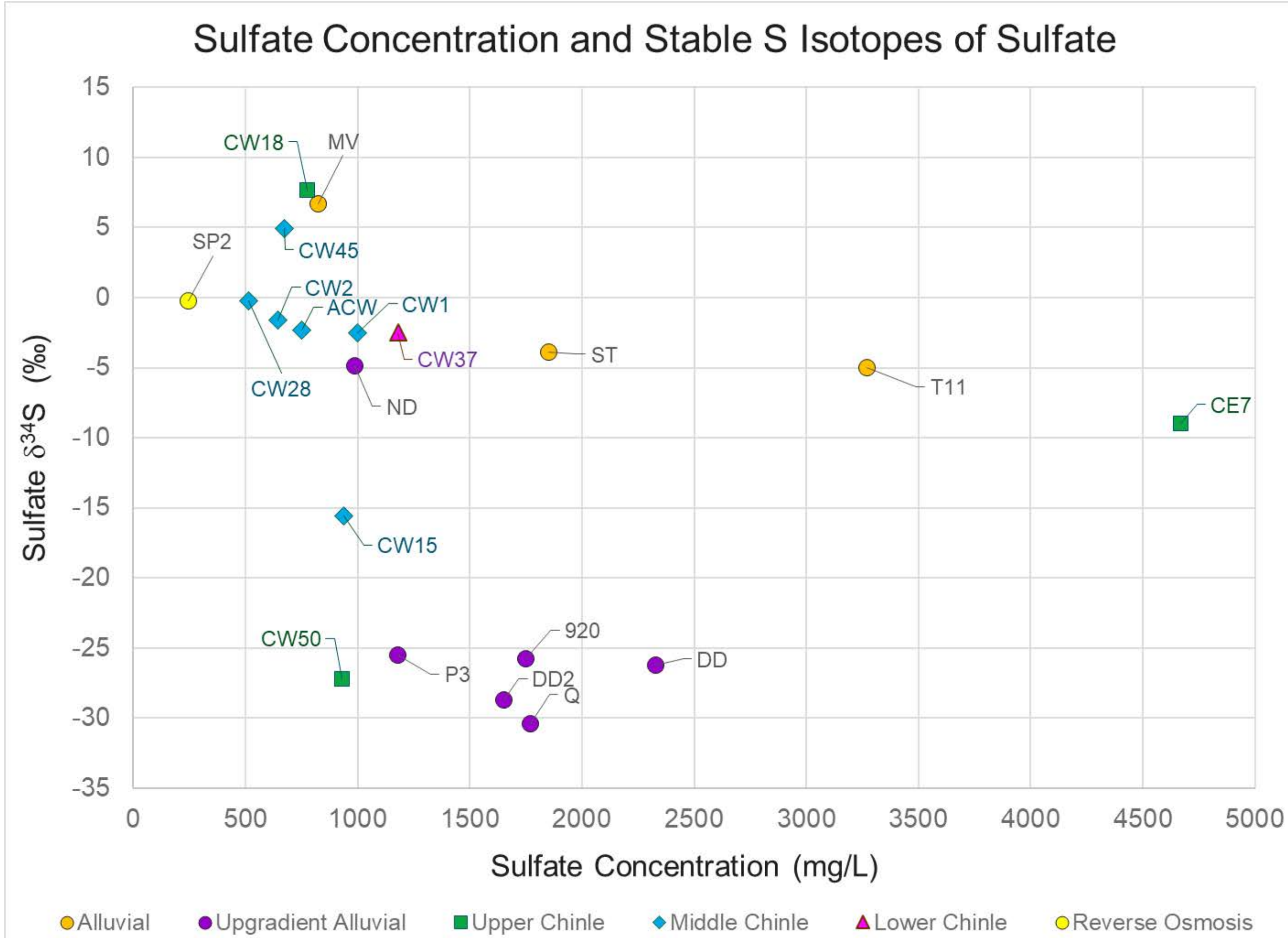
Upper Chinle



Middle Chinle

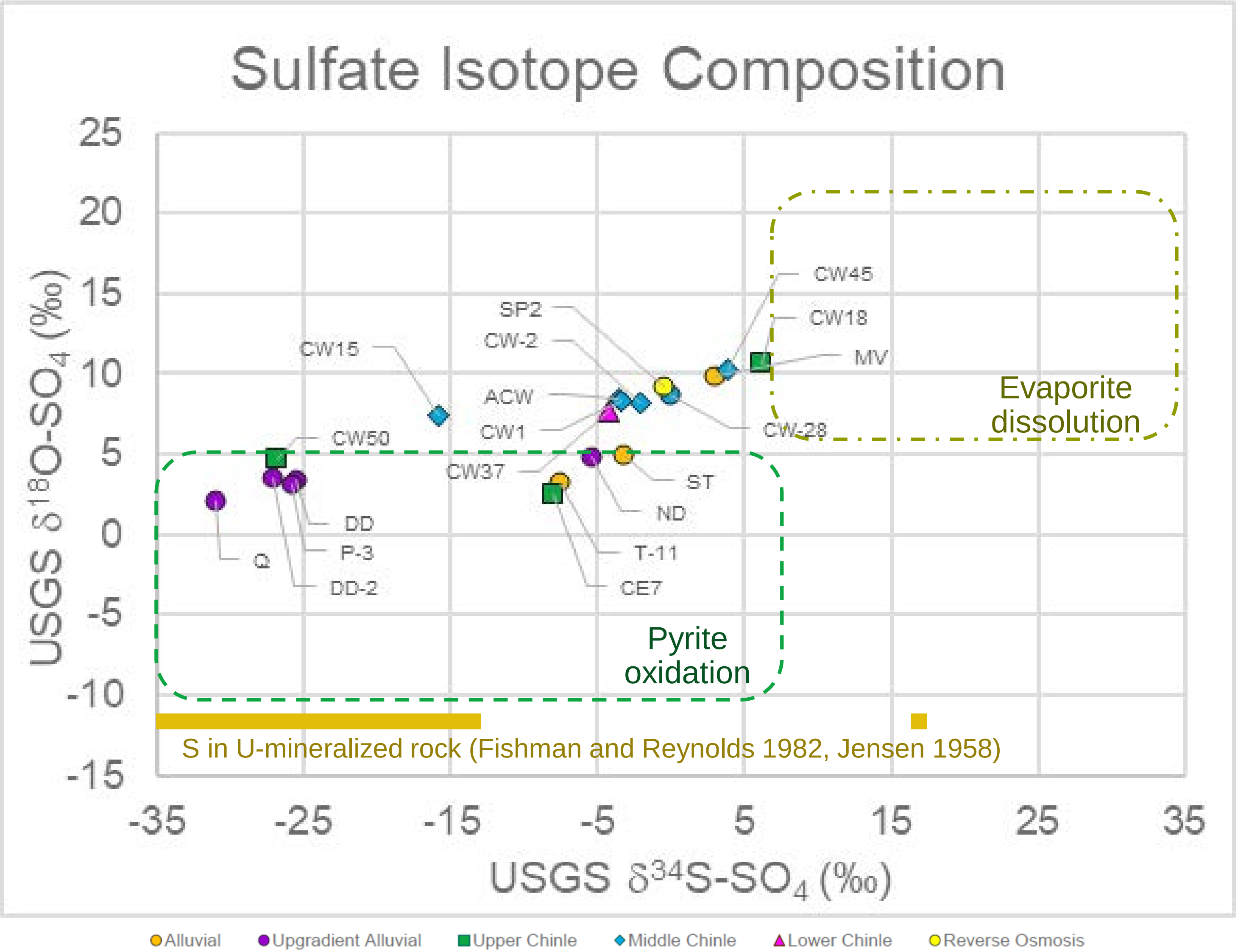
Sulfate S and O Isotopes

- Upgradient alluvial wells and CW50 plot separately from LTP wells T11, CE7, and ST. Stable sulfur isotopes suggest pyrite oxidation is primary sulfate source.
- Samples with lower sulfate concentrations and more positive $\delta^{34}S$ values suggest sulfate derived from combination of pyrite oxidation and gypsum dissolution.
- Use of sulfuric acid in U ore processing ($\delta^{34}S$ ~ -8 to 32‰) may account for the higher sulfate concentration in LTP wells T11 and CE7



Sulfate S and O Isotopes

- Region contains naturally-occurring sulfide minerals (pyrite) in U-mineralized rocks and U-mineralized sediment present in alluvial aquifer
- Oxidation of S from sulfide minerals results in sulfate formation
- U-mineralized samples from Morrison Fm (sulfide minerals) $\delta^{34}S$ -29.4 to -41.6‰ (Fishman and Reynolds 1982)
- Sulfide minerals associated with sandstone-type U-deposits $\delta^{34}S$ -13 to -41‰, one sample +17.6‰ (Jensen 1958)



Results by sample method

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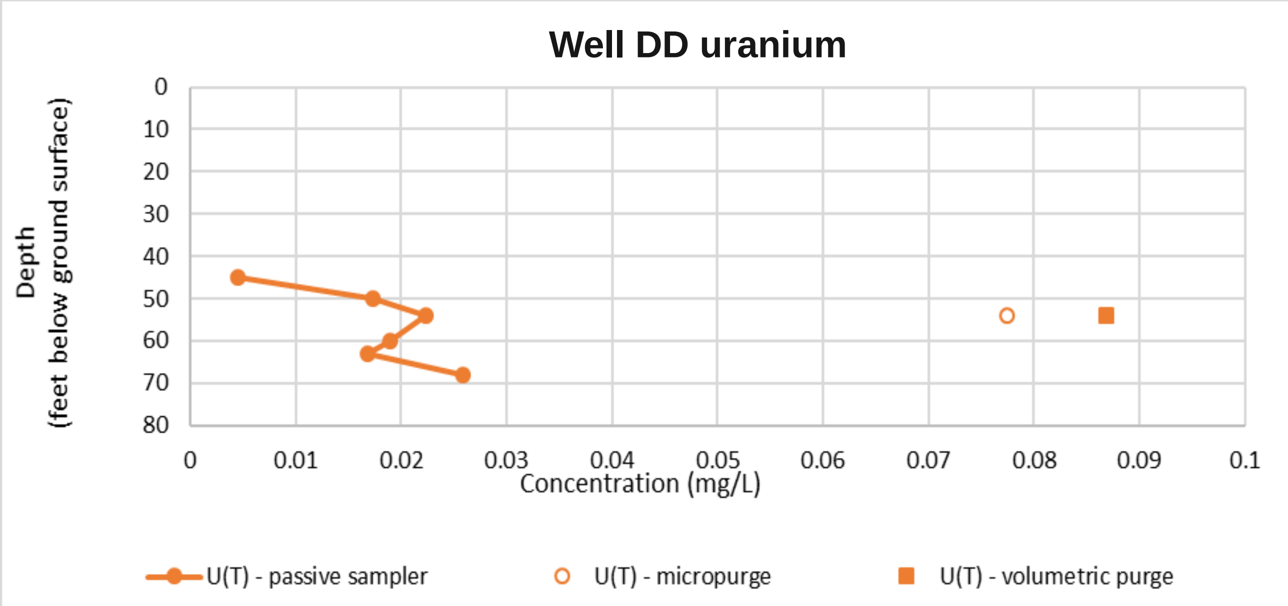
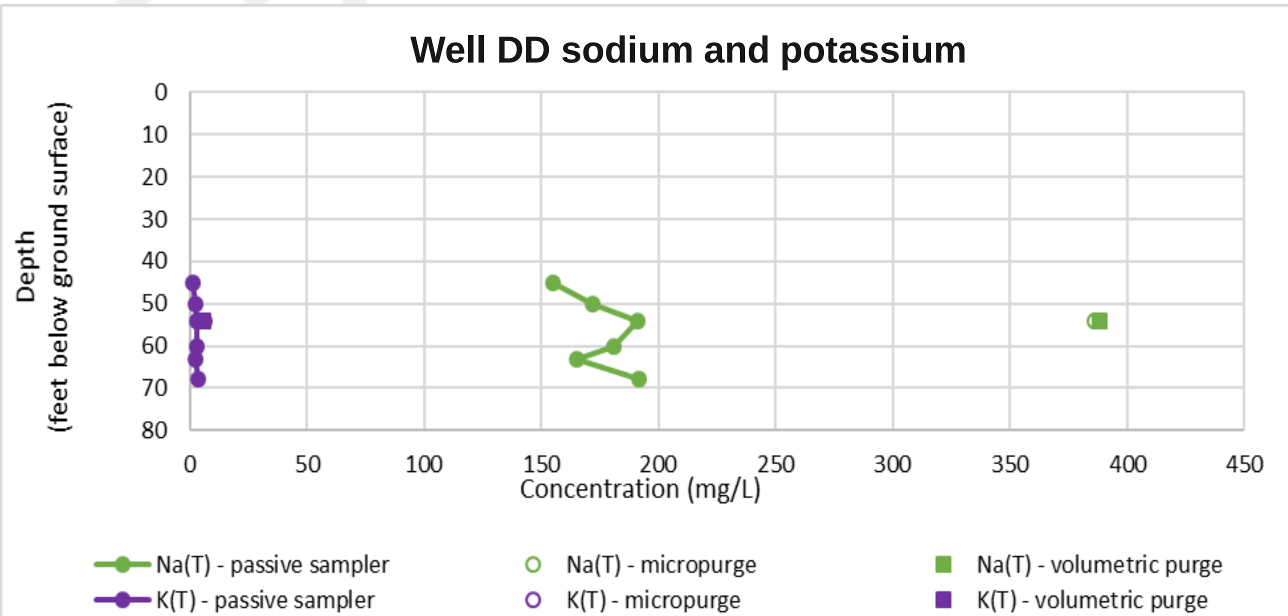
- volumetric purge
- micropurge
- passive samplers



Passive sampler << micropurge or volumetric purge

Passive sampler ≠ micropurge at same depth

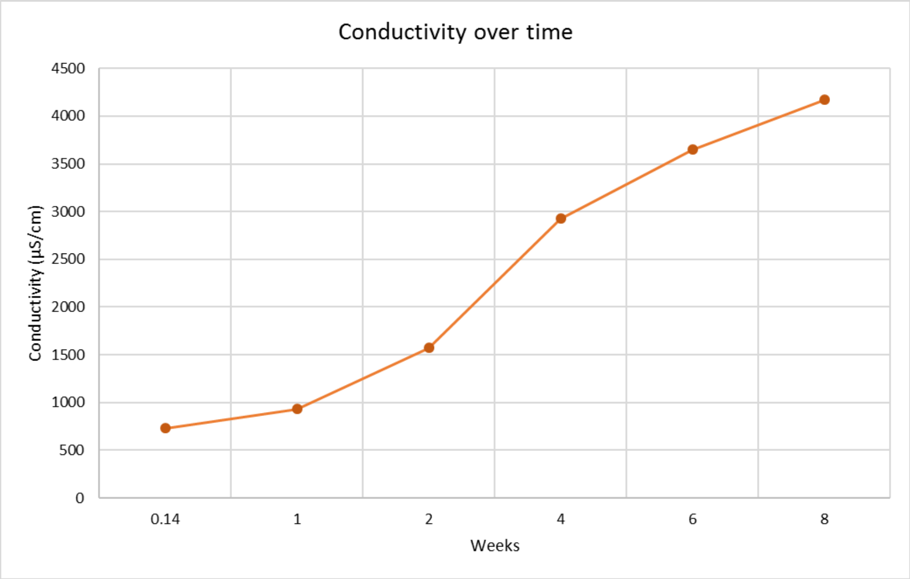
Conservative ions did not equilibrate

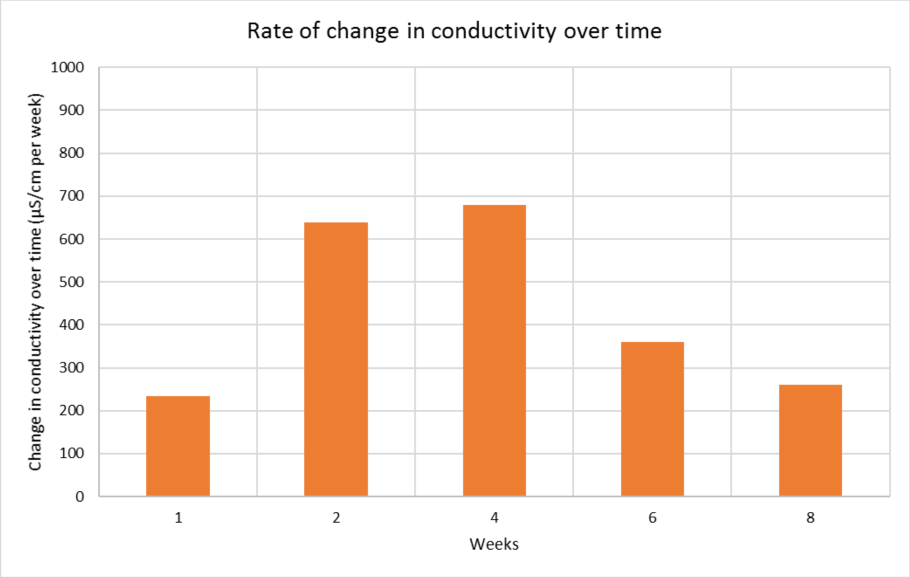


Passive Samplers – bench testing

Passive sampler bench testing results

- Conductivity was still increasing in the collected passive samplers at 8 weeks' time
- Peak change in conductivity in the passive samplers occurred at 4 weeks
- Reflects that highest mass flux was occurring around when passive samplers were collected in the field

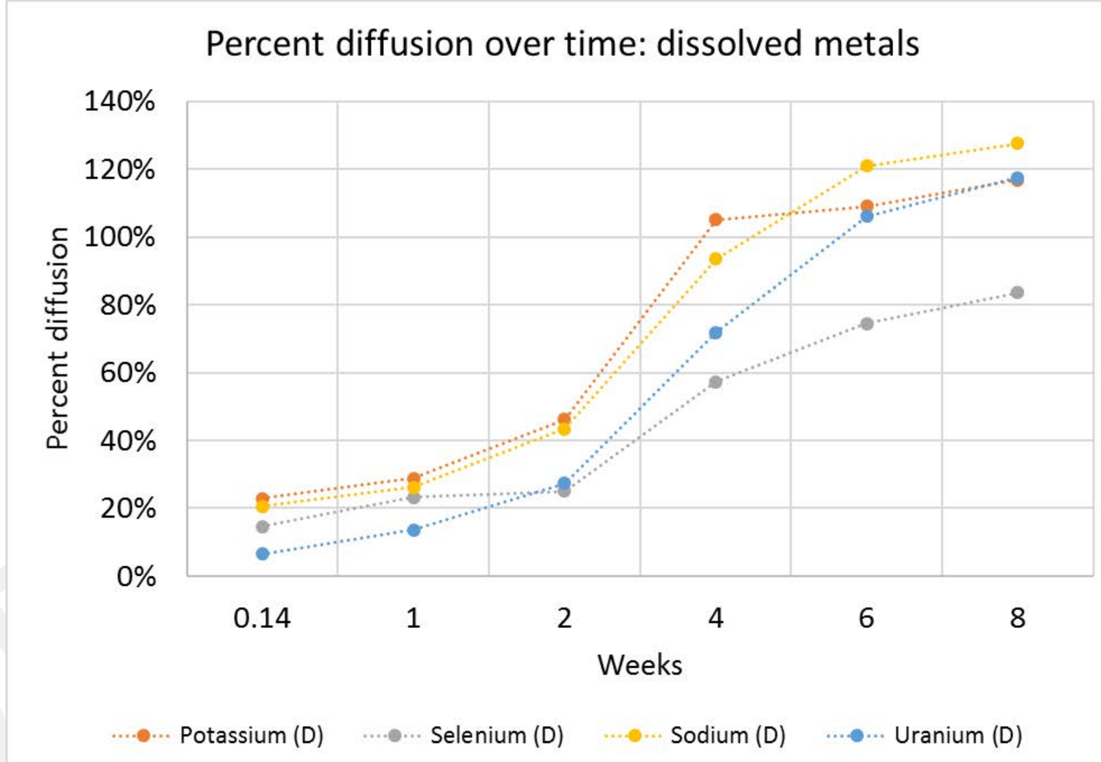




Passive sampler bench testing results

It takes at least 6 weeks, and likely 8+ weeks, for equilibration to occur

We also saw binding to the nylon mesh, including up to 5 mg/kg uranium



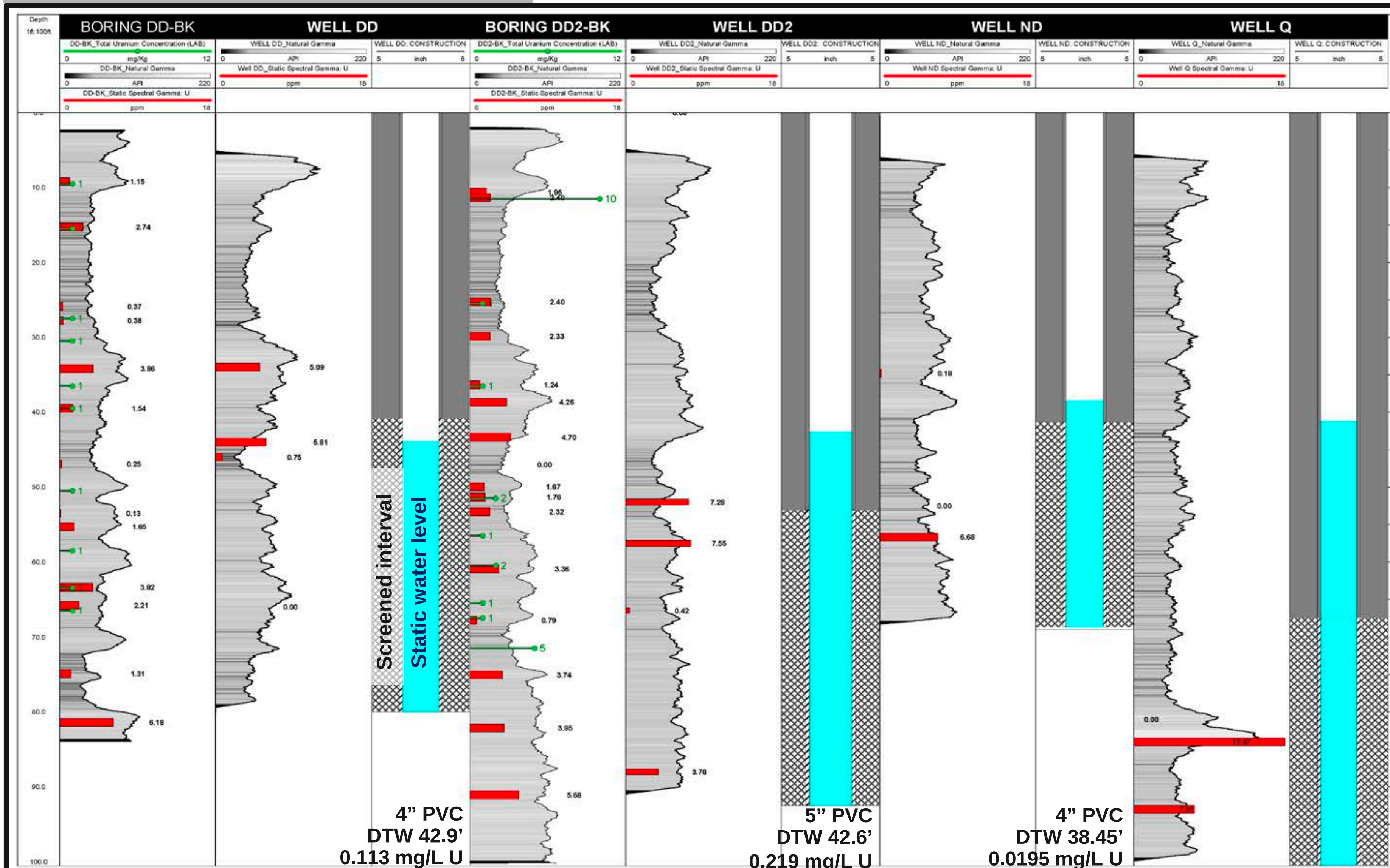
	Fully mixed solution	24hr	Week 1	Week 2	Week 4	Week 6	Week 8
Analyte	**% diffusion**	**% diffusion**	**% diffusion**	**% diffusion**	**% diffusion**	**% diffusion**	**% diffusion**
Dissolved Metals by Method SW6010B for Na and K, SW6020 for Se and U (mg/L)							
Potassium	100%	23%	29%	46%	105%	109%	117%
Selenium	100%	15%	23%	25%	57%	75%	84%
Sodium	100%	21%	26%	43%	94%	121%	128%
Uranium	100%	6%	14%	27%	72%	106%	117%

Geophysics

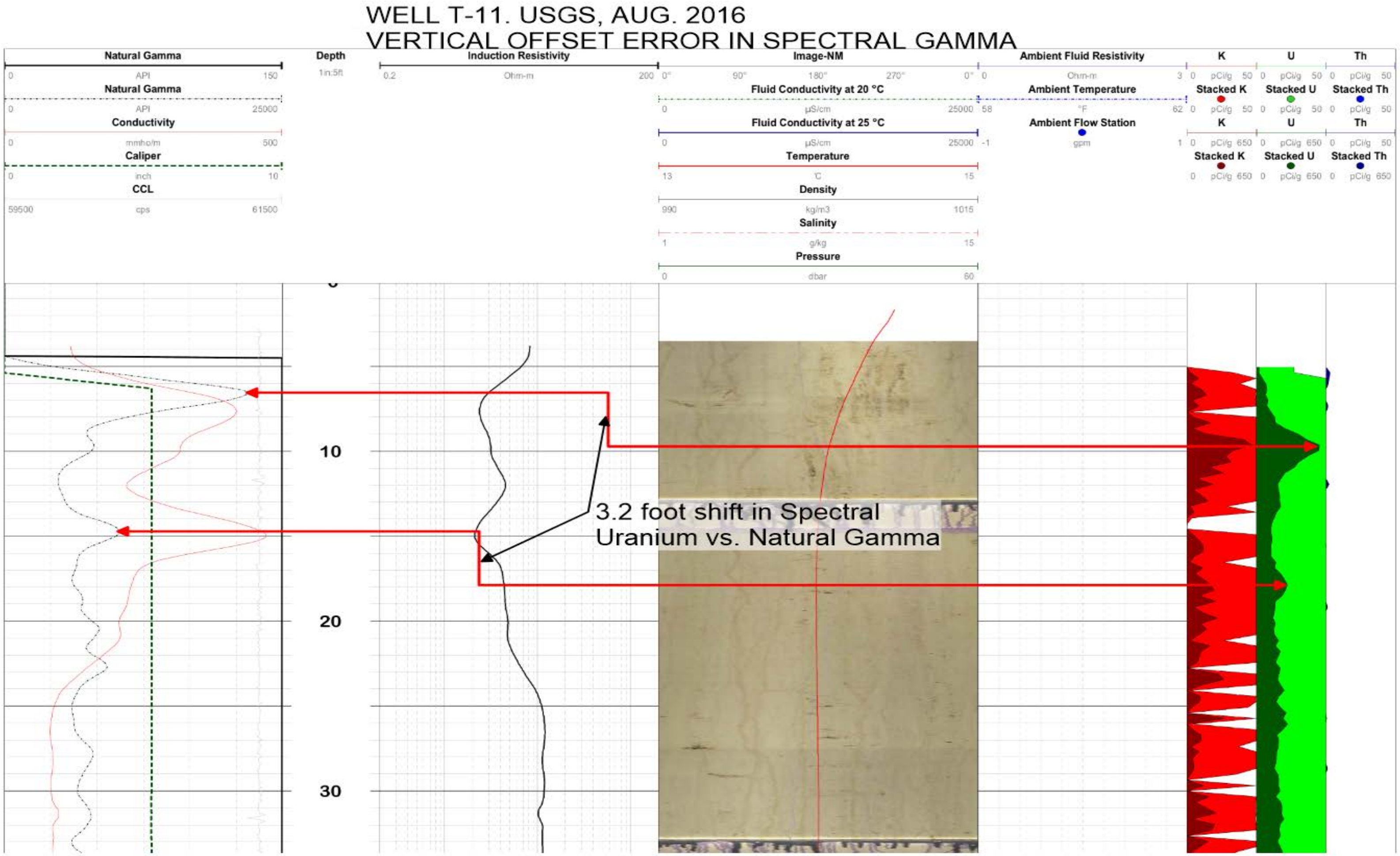
Alluvial uranium and well construction

Natural gamma
6.18 Spectral gamma
1 Total uranium in soil borings (lab analysis)

Uranium in alluvium is preferentially in fine grained sediments and varies significantly by location

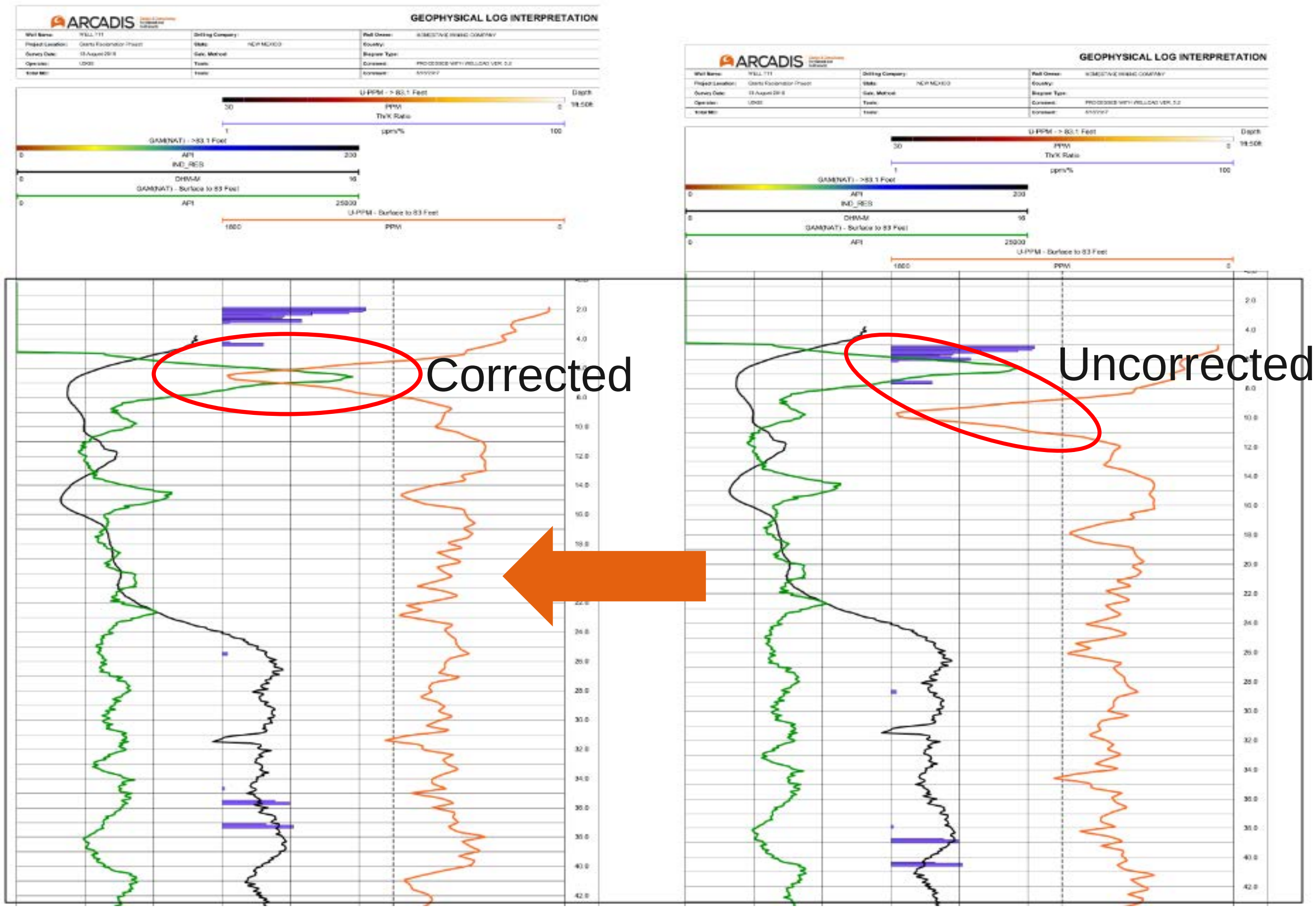


Well T11:
Spectral Gamma Shift Error



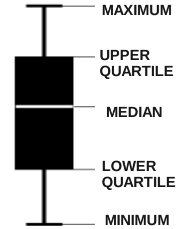
Is spectral gamma correctly aligned at the other wells?

Well T11: Spectral Gamma Shift Error

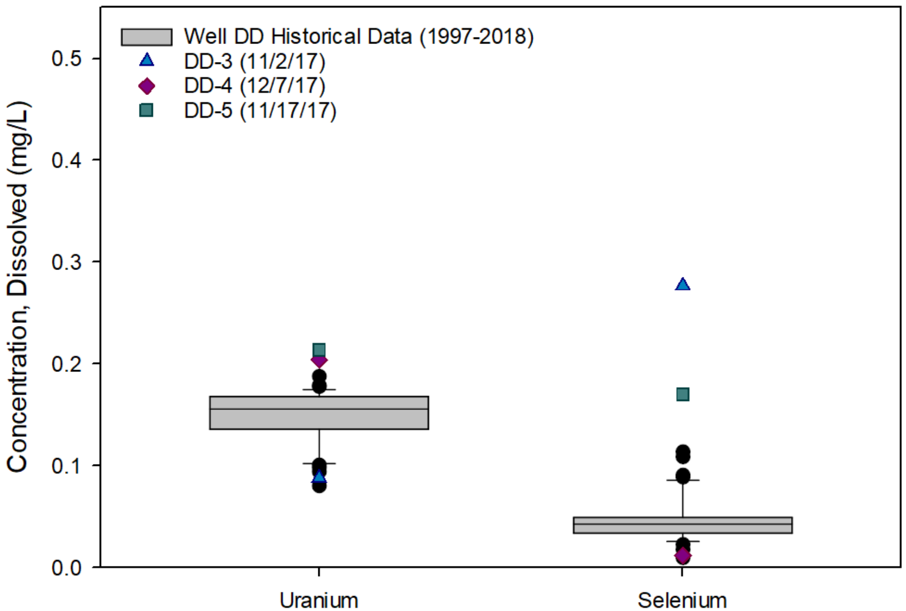


Is spectral gamma correctly aligned at the other wells?

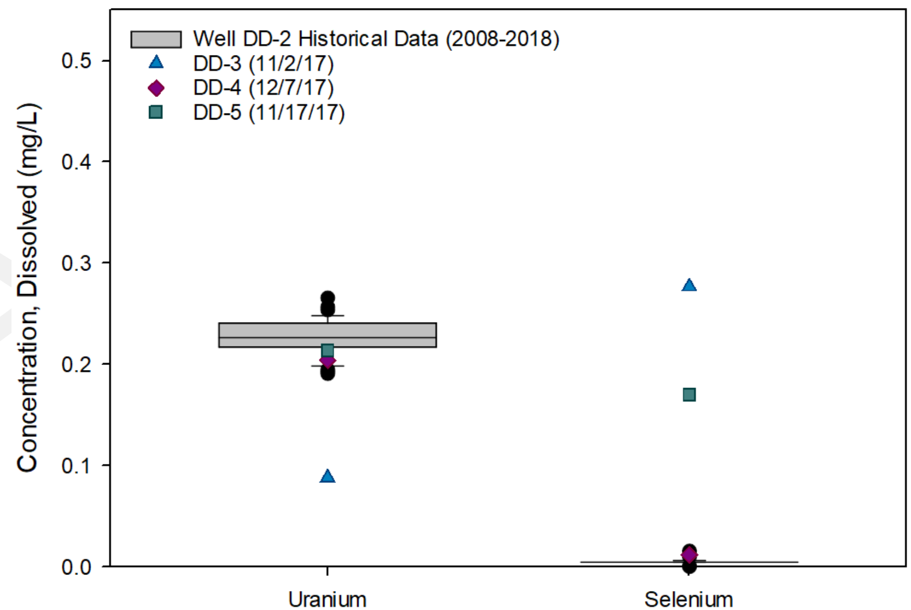
Wells DD-3, DD-4, and DD-5



Well DD



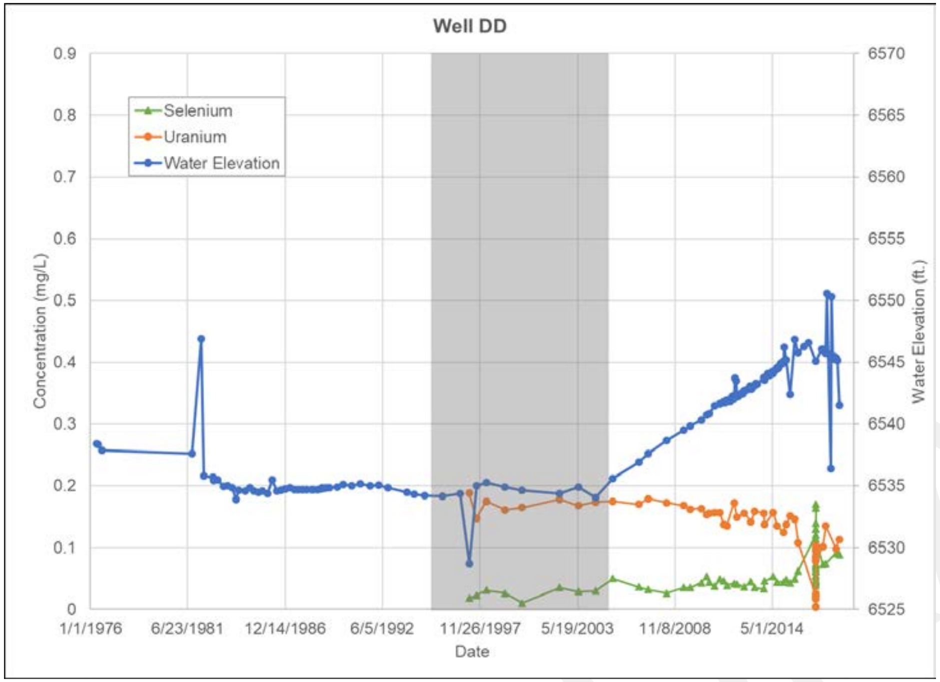
Well DD-2

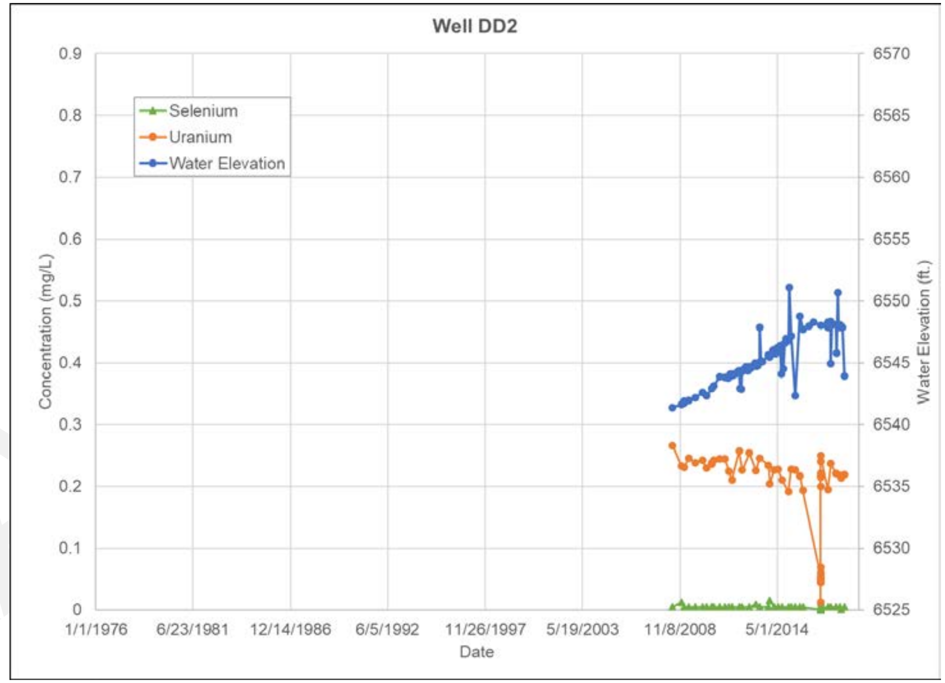


	U	Se
DD-3	0.0884	0.277
DD-4	0.204	0.012
DD-5	0.214	0.170

DD-6 and DD-7 are dry

Changes over time





- Water levels have increased, starting after collection of data for the background study in 2004
  - Due to hydraulic barrier emplaced on north side of Homestake Mill
- Selenium has increased in DD
- Uranium is decreasing in DD and DD2 since the background study

Overview of Conceptual Site Model for Upgradient Concentrations of Uranium in Groundwater:

Geophysics, and soil chemistry at DD-BK and DD2-BK

Location of boreholes

Samples with elevated uranium

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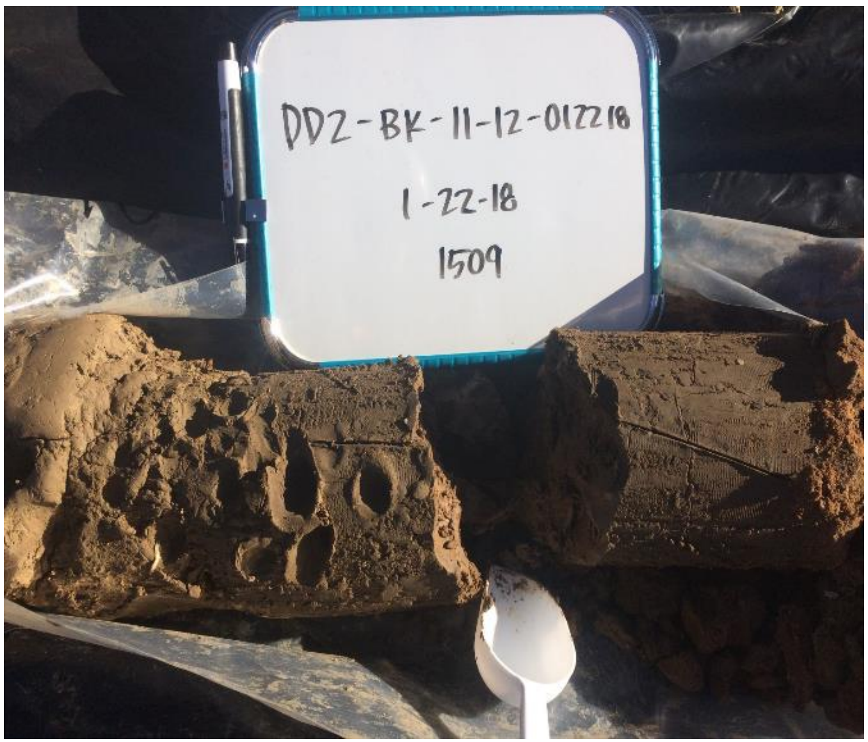
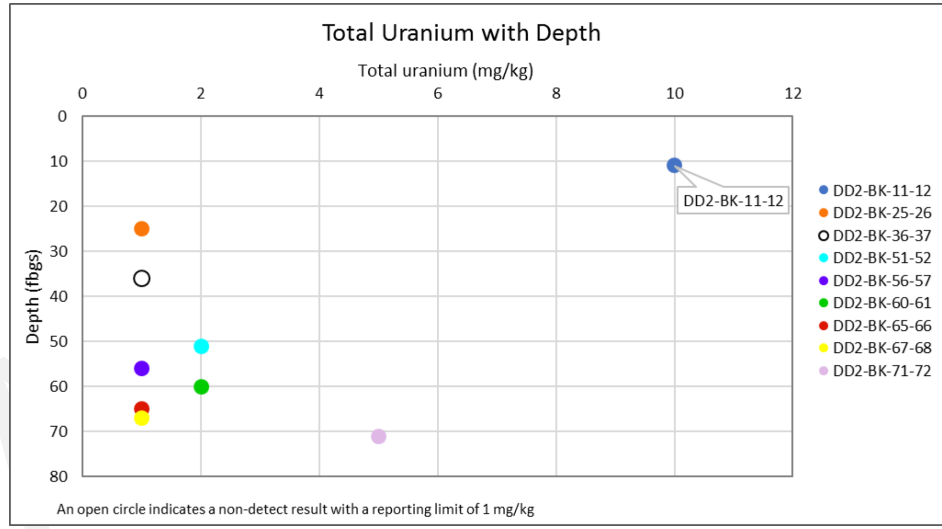
Sample ID	Alluvium zone	Total uranium concentration (mg/kg)	Alkaline SPLP leached uranium (mg/L)	Field-logged lithology	ACZ Particle Size Analysis Lithology	DCM analysis
DD2-BK-11-12-012218	unsaturated	10	0.179	CLAY	Clay	Yes
DD2-BK-71-72-012318	saturated	5	0.0305	Gravely SAND with silt	Sand	Yes
DD2-BK-51-52-012318	saturated	2	0.0086	Silty SAND	—	Yes
DD2-BK-60-61-012618	saturated	2	0.0086	CLAY with trace sand	—	Yes
DD2-BK-25-26-012218	unsaturated	1	0.0477	SAND with trace silt	Sand	Yes
DD2-BK-56-57-012318	saturated	1	0.0079	Silty SAND	—	No
DD2-BK-65-66-012318	saturated	1	0.0080	Sandy SILT	—	No
DD2-BK-67-68-012618	saturated	1	0.0180	CLAY	—	No
DD-BK-36-37-012518	unsaturated	1	0.0127	CLAY	Clay	Yes
DD-BK-58-59-012618	saturated	1	0.0032	CLAY	—	Yes
DD-BK-9-10-012518	unsaturated	1	0.0022	CLAY with trace sand	Clay	Yes

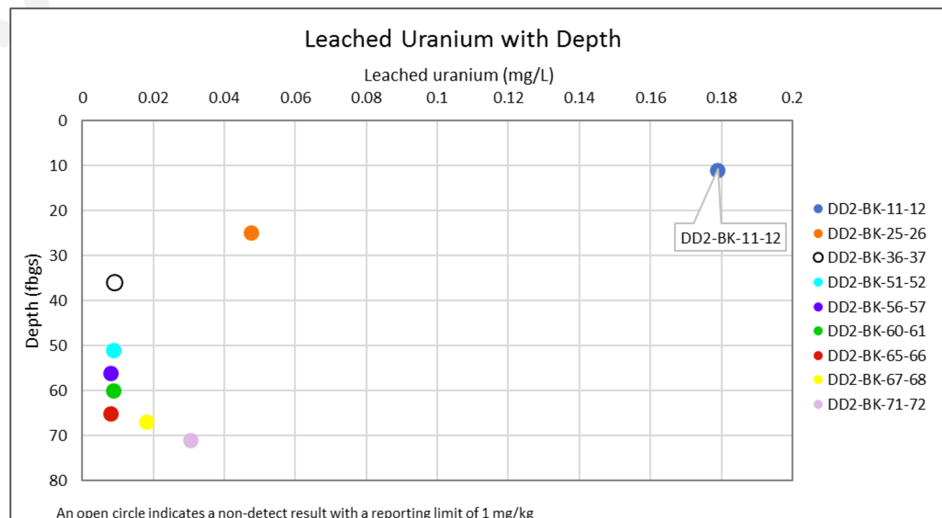
19 samples (excluding duplicate) were analyzed by ELI, only those with detectable total uranium concentrations are shown in the table

DD2-BK-11-12-012218

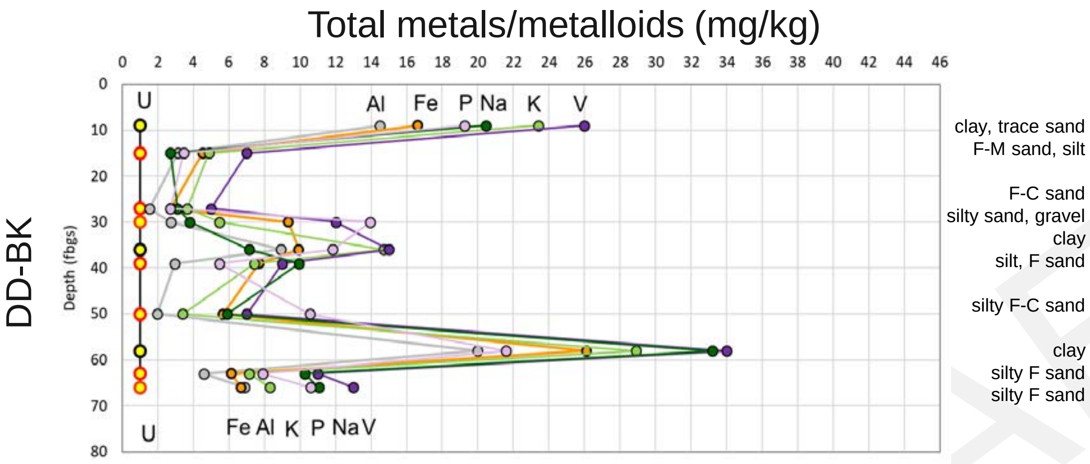
- Total uranium concentration: 10 mg/kg
- Alkaline SPLP leached uranium: 0.179 mg/L
- Lithology: Clay

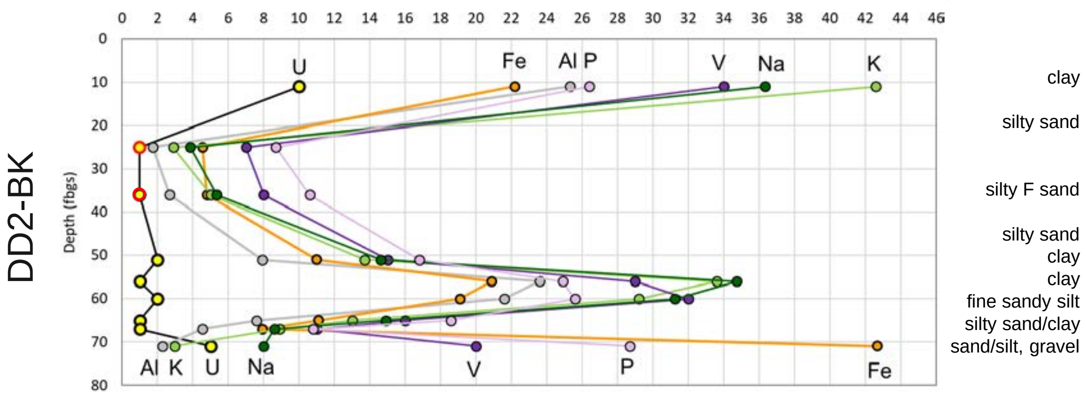






Soil chemistry – total metals

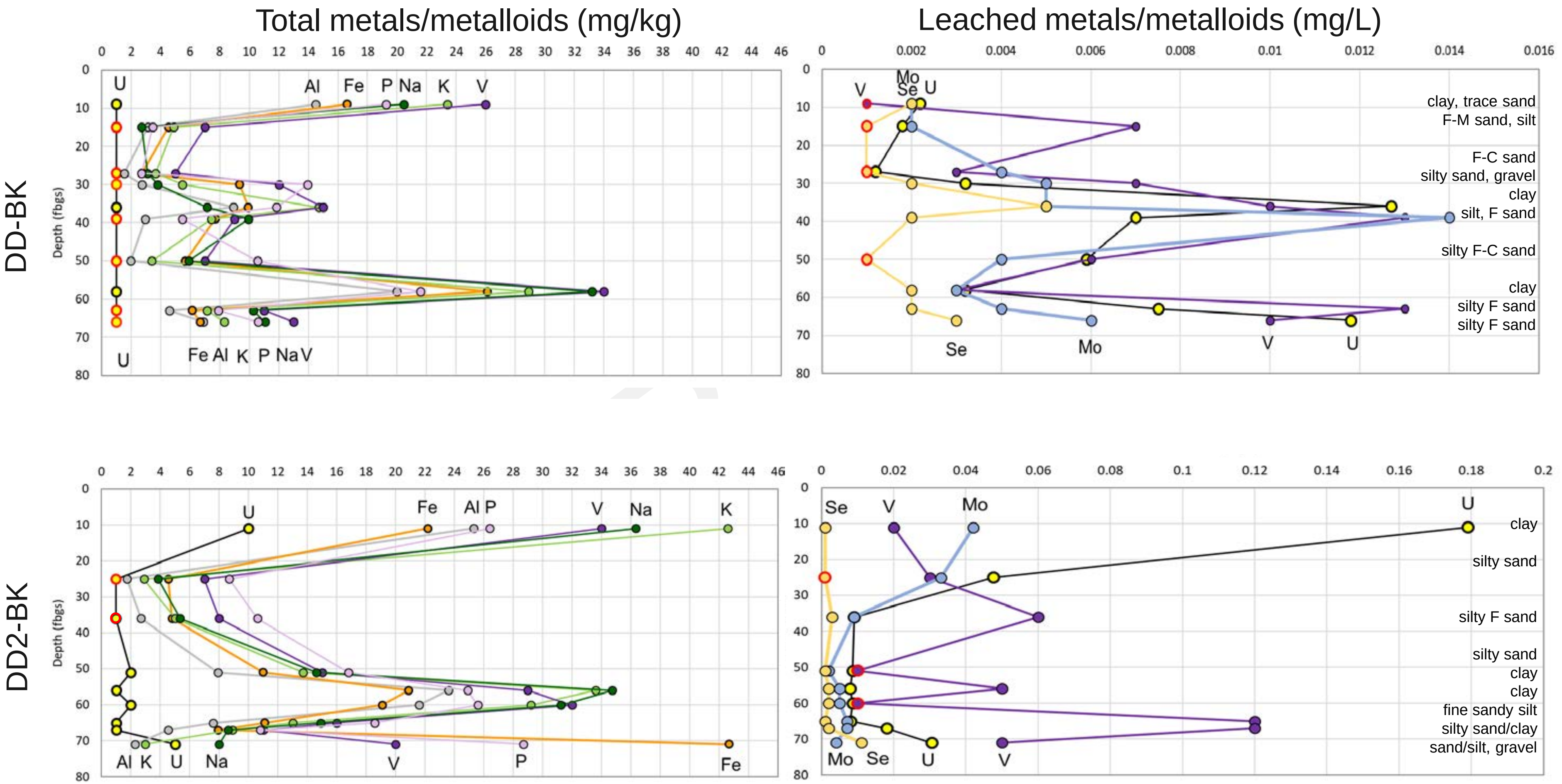




Red circle = non-detect; reporting limit shown
Total Al and Fe/1000; K/100; Na, P/20

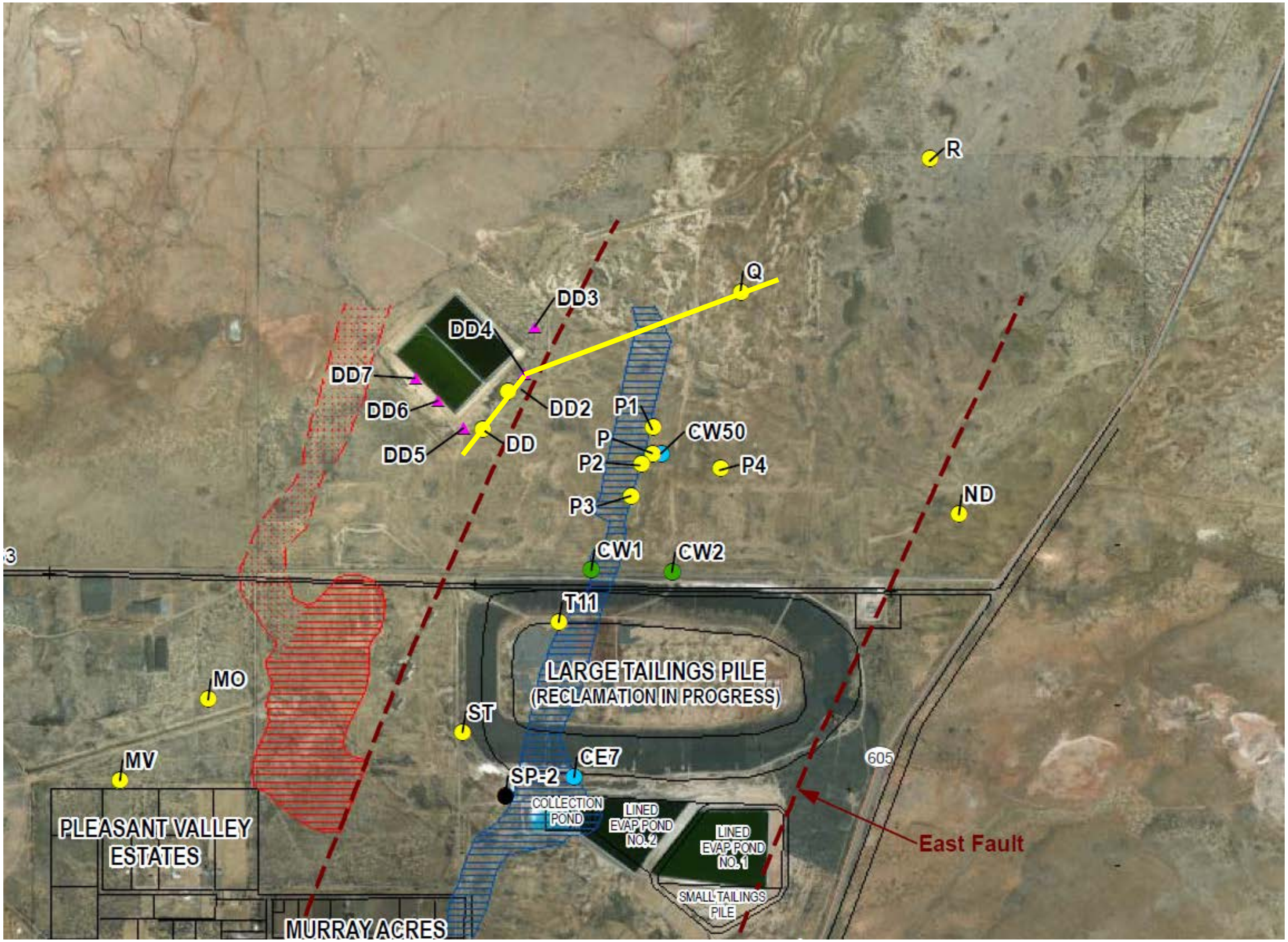
Soil chemistry – total metals and leaching

Leached in an alkaline (simulated groundwater) extraction



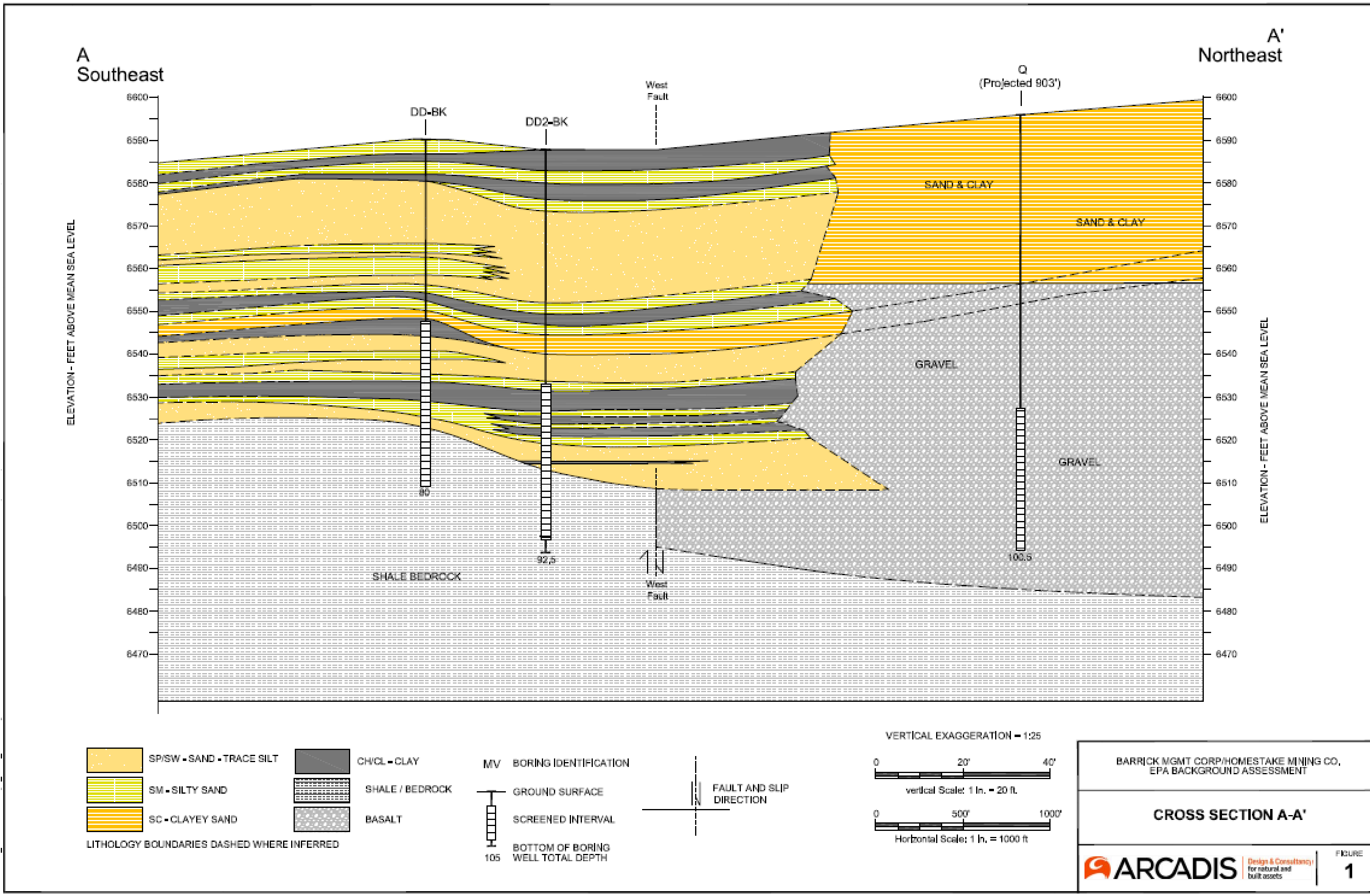
Red circle = non-detect; reporting limit shown
Total Al and Fe/1000; K/100; Na, P/20

Cross section – Location

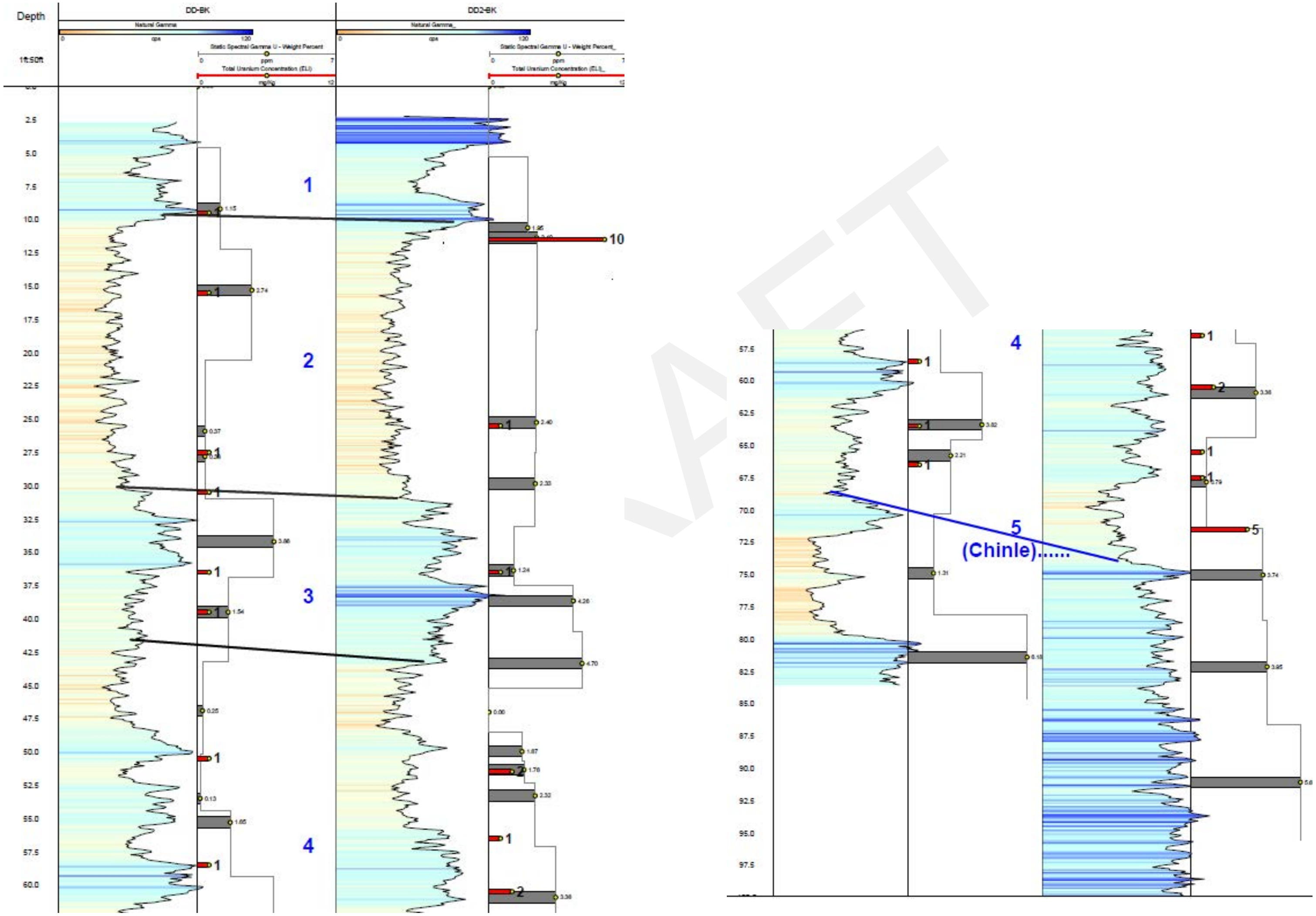


Cross section

New information in this area! Changes the overall interpretation of the DD/DD-2 area and is more consistent with depositional environment as presented by many geologists over last 100+ years

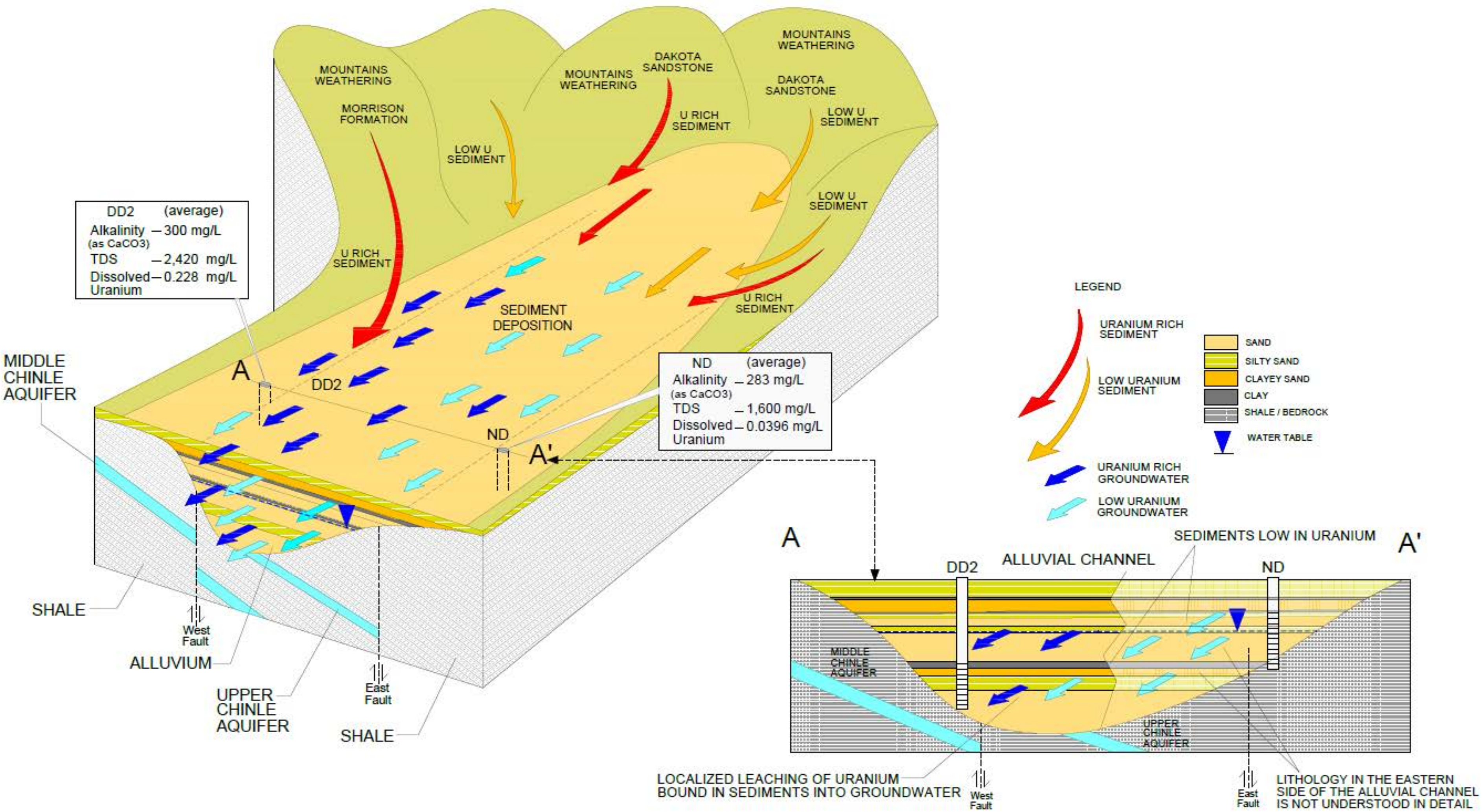


DD-BK and DD2-BK comparison natural gamma logs

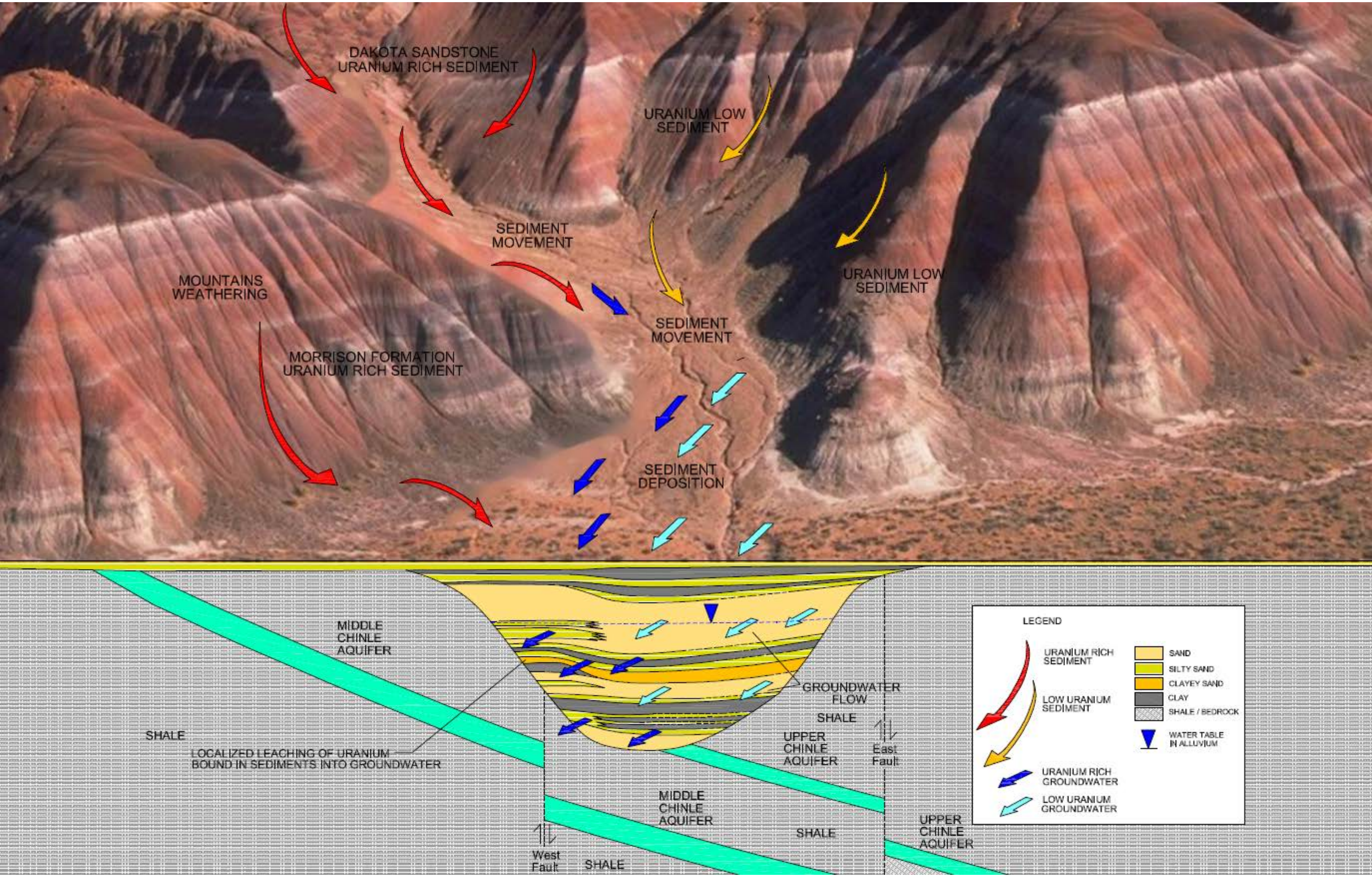


Conceptual Site Model for Naturally Occurring Concentrations of Uranium in Groundwater

CSM and X-Section



CSM Erosion Block



Conclusions

- Passive samplers in 2016 may have not equilibrated
- Geophysical results indicate uranium in alluvium is preferentially in fine-grained sediments and varies by location
- Natural background uranium from alluvial system supported by DD-BK and DD2-BK results
  - Geology is more heterogeneous than previous logs suggested
  - Variation in U concentration in soils between lithologies and also both saturated and unsaturated zones
- CSM developed for uranium migration, placement and groundwater leaching to derive variation in uranium concentrations naturally in basin
- ND well is a geochemical outlier and only represents one point in the alluvial system and as such background uranium assessment should not be based solely on this one well